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TEST TASK AND ITEM SIMILARITY FACTORS AFFECT MEMORY AND EYE MOVEMENTS DURING PICTURE RECOGNITION

by
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Bachelor of Arts, Concordia College, 1979

A Thesis

Submitted to the Graduate Faculty

of the

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in partial fulfillment of the requirements

for the degree of

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This Thesis submitted by David Paul Lommen in partial fulfillment of the requirements for the Degree of Master of Arts from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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A. William Johnson 12/5/83
Dean of the Graduate School

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Title Test Task and Item Similarity Factors Affect Memory and Eye Movements During Picture Recognition

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Signature David Loomer

Date November 30, 1983

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ABSTRACT

The purpose of this study was to explore how recognition memory for pictures and eye movements vary depending on the type of test and the nature of the "related" distractor items. Prior research suggested that manipulation of test type and distractor similarity both influence recognition memory. The present study crossed test type and composition (kind of distractors) in a 2 X 2 design.

Forty-eight undergraduates viewed an input list of 58 scenic, color photographs of cityscapes and landscapes. The memory test was composed of 12 "Same Photo" items, each identical to input list photographs; 12 "Related" items, each visually similar in certain respects to input list photographs; and 12 "Lures," each unrelated to input photographs. Half of the subjects viewed, as related items, "Mates" (adjacent views to the left or right of input photographs) and half viewed "Reversals" (left/right reorientations of input photographs).

"Resemblance" and "Discrimination" test conditions were used in this study. Under Resemblance test instructions, subjects were instructed to identify both Same Photo and Related items as "old," and Lures as "new."

Under Discrimination test instructions, subjects were told to identify only Same Photos as "old" and Related items and Lures as "new."

Eye movements were recorded at test using a Gulf and Western Eye View Monitor, and the data were stored via computer. Subjects had up to 10 seconds to make each old/new judgment.

Recognition accuracy analyses indicated a Test X Composition interaction. Best performance was achieved in the Resemblance/Reversal condition, while worst performance occurred in the Discrimination/Reversal condition. Eye movement parameters indicated different search strategies during recognition, e.g., analysis of the number of fixations showed an interaction such that, in the Discrimination condition all items received a similar number of fixations, but in the Resemblance condition more fixations were shown for Lures than for Same Photo items. Results indicate the importance of retrieval factors in recognition memory for pictures.

CHAPTER I

INTRODUCTION

This paper addresses the question "How do we remember what we see?" A significant amount of our thought is shaped or determined by the memories we have, and these memories are inextricably linked to the way we perceive the visual stimuli of our environment. Research studies have importantly contributed in furthering our understanding of the variables influencing memory. Within the vast rubric of memory research, memory for visual stimuli is but one prominent focus. While much attention has been given to memory for events and language processes (and there are many other aspects of memory which have been heavily researched), a primary area of exploration of perceptual mechanisms in memory deals with recognition memory for pictures.

During picture viewing, our perception is influenced by a visual scene's physical characteristics--the size, shape, color, and other qualities of the objects in the picture. These characteristics all contribute to provide an overall impression, and part of this overall impression may be called the picture's aesthetic appeal. It seems likely that an overall impression, subjectively based, may be of more importance in the perception and subsequent memory of visually rich naturalistic photographs, than, say, simple line drawings. Overall impressions may be more likely formulated, as a matter of course, for visually complex stimuli, whereas for visually parsimonious stimuli more attention may be focused upon specific objects or attributes. With few objects present, the value of formulating an effective scene schema (perceiving the spatial composition and interrelationships of objects) is enhanced.

A visual scene, therefore, may contain characteristics which make it unique or unusual (and thus easier to remember), or more frequently, the scene may be visually similar in certain respects to other scenes we have seen in the past. The concern here is with real-life pictures. Certainly there exist degrees of "similarity" between two scenes. Our present impressions of a visual scene may be greatly influenced after comparing (consciously or unconsciously) the present one with similar previous scenes. Sometimes the more closely related two scenes are, particularly when each is relatively unfamiliar, the more likely we will confuse one for the other. When a distinctive or incongruous characteristic stands out, e.g., a polar bear in a desert, confusion may be less probable.

Most real life scenes do not contain specific features which tend to impart uniqueness. Many, on the other hand, contain objects which are not mundane to the extent that all objects of that class (for example, trees) look alike. Memory for pictures has been shown to be best when unique or incongruous objects are present (e.g., Loftus & Mackworth 1978), and next best memory would seem to be for pictures containing objects relatively different, or a group of objects perceived in an unusual relationship (for example, snow covered ground next to a gurgling brook may be considered somewhat unusual). Accurate memory does not always rely upon object recognition, but is aided by it (e.g., Loftus & Bell 1975). Perhaps most visual scenes could be placed in this category.

What happens when this "resolution gap" is further narrowed, i.e., when no unique or even relatively unusual object or objects are present, and when "detail components" have been effectively eliminated? Many real life scenes do not contain outstanding features. Often when we view a scene, the various qualities all contribute to give an overall impression (perhaps this may partly explain memory differences between "detailed" pictures and ordinary, non-detailed pictures). The synthesis of ingredients often marks "uniqueness," but the uniqueness is usually of such a complex nature that confusion with other scenes close in resemblance still may occur quite often. In these cases we may have an "overall impression" but the overall impression is not a very adequate device in facilitating future recognition. The "boundaries" for recognizing this type of picture (in the future) may be unclear, so we confuse the picture with anything closely resembling it (also involved, among other factors, is how well we studied the picture). Pictures of this sort are arguably more purely "visual" than pictures with specific, "verbally nameable" objects. Likewise, even with pictures containing verbalizable details, other pictures with similar verbalizable details may be kept distinct visually but not verbally. For example, two photographs of the same mountain scene (containing the same details) may not be recognized as being the same, if one photograph was taken at night and the other in bright daylight. Assuming none of the details in the "dark" photo were obscured, memory is contingent on light/dark features, and the relative contribution of specific details has been eliminated. A more purely visual condition has been imposed in this case.

Obviously, a number of other variables are important in picture recognition, beyond the specific qualities and characteristics of the stimulus itself. Experimentation has primarily been concerned with distinguishing which of these "extraneous" influences are important and which are not important. This is the subject of the following section.

CHAPTER II

LITERATURE REVIEW

Research oriented toward discovering perceptual mechanisms involved in recognition memory for pictures has been directed along several disparate routes. While it has been conceded that recognition accuracy is generally quite good (Haber 1970; Shepard 1967), the precise nature of variables contributing to accurate recognition of pictures has been largely unexplored until recently. Various approaches and emphases have been used, for example, manipulation of expectation of a recall or recognition test (Bahrick & Boucher 1968; Tversky 1973); distractor tasks at study (Freund 1971; Loftus 1972); manipulation of study time (Potter & Levy 1969); analysis of detail versus general information recognition (Loftus & Bell 1975; Loftus & Kallman 1979) and scene schema (Mandler & Ritchey 1977); analysis of age differences (Till, Bartlett, & Doyle 1982); tracing eye movements (Loftus 1972; Tversky 1974); administration of verbal tasks at input (Bartlett, Till, & Fields 1980); and so on.

There exist a number of ways of explicating what contributes to accurate memory for pictures. A potentially useful approach in obtaining a better understanding of research in memory for pictures consists of conceptualizing in terms of "encoding" and "retrieval" processes (e.g., Woodworth 1938). While this paper does not intend to present extensive arguments on the relative merits of either encoding or retrieval explanations of memory, it seems safe to assert that encoding and retrieval has been a dichotomy imposed upon explanations of memory, for the sake of research. In a real-life situation, they are undoubtedly intertwined. Nevertheless, the isolation of memory elements has proven useful.

Encoding Manipulations

There are many ways to influence the outcome of a memory experiment. For example, Craik and Lockhart's (1972) "levels of processing" model has provided a useful framework with which to conceptualize how "trace persistence" depends upon the depth of processing. In the past ten years or so, the impetus given to researchers by this and other memory frameworks has led to numerous experiments containing manipulations of study conditions, orienting tasks, and encoding variables. A large number of the studies within Craik and Lockhart's (1972) model have utilized verbal materials at input, but few have been done on picture memory. However, a number of studies investigating picture memory have been done outside the framework, and the following few examples are intended to provide a small sampling of research in the area.

One interesting manipulation has been expectation of a recognition or recall memory task (Bahrick & Boucher 1968; Tversky 1973; Frost 1972). Frost (1972) found that subjects expecting a recall memory task tended to access "semantic" information more efficiently and subjects expecting a recognition memory task accessed "pictorial" information more efficiently. Apparently, pictures are encoded into memory differently, depending on the expectation of test type. Furthermore, Tversky (1973) found no correlation between recognition and recall of an item; neither did Bahrick and Boucher (1968).

Another technique employs the use of distractor tasks. Loftus (1972) had subjects count backwards by threes while viewing an input list of pictures, and found that memory performance (and number of fixations) was reduced. Freund (1971), using a similar procedure, also found memory to be impaired by the distractor task. What has been suggested in both of these studies is that viewing while counting backwards yields "somewhat different information than normal viewing."

A final example of memory outcome being determined during encoding is the manipulation of study time. A very common-sense assumption is that memory performance should correlate positively with viewing time (Potter &

Levy 1969). In addition to other manipulations, Loftus and Kallman (1979) controlled exposure times from 50 to 1000 msec., and found that the encoding of details leading to accurate recognition was more probable over time, and longer exposure times predicted more accurate memory.

It seems obvious even from a short review that a number of manipulations at the time of study can significantly affect memory results. The previously cited studies were intended to provide a small, representative sampling of research in this area.

Retrieval Manipulations

"Retrieval" manipulations may be said to represent the counterpart of encoding manipulations in memory experiments. A good example of retrieval manipulation is seen in a series of experiments by Mandler and her colleagues (Mandler & Johnson 1976; Mandler & Parker 1976; Mandler & Stein 1974; Mandler & Ritchey 1977). All these experiments explored the notion of "schemata" and how they influence memory. The types of information thought to be included in schemata consisted of inventory information (the objects a picture contains), descriptive information (the figurative detail of objects), spatial location information, and spatial composition information (i.e., empty vs. filled space in the picture). Recognition was then compared using a number of transformations, e.g., a "token change," in which an object was replaced by another object of the same conceptual class (but different in appearance); or an addition, in which an object was added to the picture. Results generally indicated that a scene schema contains an inventory of objects and their locations relative to each other. No descriptive information about the objects or overall spatial composition of the scene was retained over time. Long-term retention was more heavily dependent upon scene schemata than short-term encoding. The assumption made that drawings of scenes (as used by Mandler and her colleagues) are encoded the same as more realistic scenes (i.e., naturalistic photographs) must be questioned, however.

Encoding and Retrieval

It appears that some studies arguably contain both encoding and retrieval manipulations (e.g., Loftus & Kallman 1979). The distinction between encoding and retrieval is by no means clear, particularly in the cases where encoding variables overlap with retrieval variables (i.e., manipulation of memory task-type and analysis of semantic vs. pictorial information codes). In this regard, a discussion may focus on a verbal/visual dichotomy of human memory (Paivio 1965).

In attempting to gain a greater understanding of factors contributing to accurate recognition memory, the distinction has often been made by various researchers in separating, or attempting to separate, "verbal" and "visual" information into respective codes (Loftus & Bell 1975; Bartlett, Till, & Levy 1980; Loftus & Kallman 1979; Kintsch 1970). It has been postulated that recognition memory performance is principally based upon the general visual information a picture imparts, while recall memory is based upon a specific detail component (Bahrick & Boucher 1968). This conclusion may be too simple, and is based on evidence derived from the use of simple line drawings, not complex, naturalistic visual scenes. It has been demonstrated that the encoding of a specific detail is more beneficial for both recognition and recall tests (Freund 1971; Loftus & Bell 1975; Loftus & Kallman 1979). But to further complicate matters, manipulation of types of recognition test has resulted in more efficacious encoding <u>either</u> verbally (detail) <u>or</u> visually (Bartlett, Till, & Levy 1980).

A great deal more evidence supports this dichotomy. The issue is complex, and seems to hinge upon a number of factors, including type of stimuli (Bahrick & Boucher 1968), difficulty of stimuli at test (Bartlett, Till, & Levy 1980), imposing a detail "set" on subjects at input (Loftus & Kallman 1979), and number of informative areas in the picture (Loftus & Bell 1975). The assertion by many researchers that there indeed appear to be two somewhat distinct types of information in picture memory seems to be valid, but the ways of demonstrating this idea have varied widely. Loftus and Bell (1975), in their report, went so far as to say that as long as a detail was encoded at input, that "memory performance is not substantially affected by target complexity, exposure time, or presence or absence of a mask" (p. 103). Several assumptions were implicit. First, specific detail information was likened to the verbal component of picture memory, and thus the contribution of general visual information to memory would seem to be of secondary importance in recognition. Nevertheless, preventing verbalization in this study did not lead to chance performance, indicating some role for general visual information. If Loftus and Bell (1975) are correct with this assumption, Mandler and Ritchey (1977) mistakenly assumed that general information consists of the sum of details that subjects encode, and general information would thus represent the "apex" of verbal encoding. Another assumption was that the absolute number of informative areas was assumed to be critical and not the relative distinctiveness of each detail. Thus, five "ordinary" details would aid encoding more than three "unusual" details.

A more general error may be that researchers have tended to ignore the issue of test item difficulty/complexity. Little systematic exploration has been done in explicitly controlling the relationship between target and distractor photographs. Bartlett, Till, and Levy (1980) and Bartlett, Till, and Fields (1980), however, employed "Resemblance" and "Discrimination" test conditions to provide a more sensitive measure of test difficulty. These test conditions were effective in delineating effects of label distinctiveness (Bartlett, Till, & Fields 1980) and effects of verbal encoding (Bartlett, Till, & Levy 1980). Under the Discrimination test condition, subjects ideally accepted (considered "old") only exact copies of previous input list items, and rejected (considered "new") both lures and photographs which closely resembled input items (related items which were similar to exact copies in certain operationally definable ways). Under the Resemblance rubric, both exact copies and related items were ideally considered old and only lures considered new. In such a paradigm, then, three types of test photographs were used: exact copies of input items, related items, and lures. (Under Discrimination test instructions, related items <u>functioned</u> as "lures" but had specific features in common with exact copies which wasn't the case for lures.) This approach seems to provide a more rigorous and potentially informative test of recognition memory than the simple classification of old/new traditionally used in picture recognition studies (for "traditional" examples, see Loftus 1972; and Loftus & Kallman 1979).

The rationale for this approach is similar to that of a study by Kintsch (1970) in which recognition memory in bilingual subjects was tested using German and English nouns. Depending on the test task instructions (two of which were analogous to resemblance and discrimination instructions, respectively), subjects efficaciously responded on the basis of either language-specific or general semantic cues, i.e., language specific cues aided in discriminating between a noun and a semantically similar (but not identical) word in the other language, while general semantic cues enabled one to categorize these two types of words as the "same." Extending these instructions to memory for pictures, one may hypothesize that appropriate cues for discriminating between highly similar and highly dissimilar photographs will differ. In fact, this was demonstrated using verbal tasks (Bartlett, Till, & Levy 1980). In this study of retrieval characteristics of verbal and visual information, verbalization of details at input proved beneficial in later discriminating between "verbally dissimilar" photographs, but not in discriminating between "verbally similar" photographs. Thus, selective verbalization effects depended on the kind of recognition test.

When a subject views a picture during the testing phase, a picture which is very similar along certain dimensions to an input list photograph, the advantage of encoding "verbal" (or detail) information has been effectively eliminated. Memory performance should understandably be worse in this situation (Bartlett, Till, & Levy 1980), compared to when details are encoded (Loftus & Bell 1975). As previously mentioned, when Loftus and Bell (1975) prevented verbalization of details at the time of study, performance declined. On the other hand, for easily discriminable items, the relative contribution of verbal "detail" information should be very beneficial and distinctly improve memory performance (Till & Bartlett 1979; Bartlett, Till, & Levy 1980).

<u>Research Employing Eye Movement Analyses</u>

There are other ways to approach the issue of what contributes to recognition memory, besides analyzing effects of encoding tasks. A relatively unexplored yet potentially useful technique in delineating retrieval factors in recognition memory for pictures involves eye movement analysis: for example, eye movement patterns are believed to reflect internal cognitive processes such as attention (Nesbit 1981). It is hoped that fixation patterns will shed light on the nature of allocation of attention during the process of memory judgment. Thus the present experiment, in addition to examining recognition memory data, examined eye movements at test. Before specifically addressing the issue of eye movements and recognition memory for pictures, however, a short review of how studies utilizing eye movement analyses have contributed to the study of general cognitive processes may be helpful.

While it has been pointed out that many past studies performed in the area of visual perception have utilized presentations of single, tachistoscopic exposures, and therefore are questionable in terms of how well they parallel real-life, "continuous" visual perception, other studies have sought a higher degree of ecological validity by examining the relationship between eye movements and performance on various cognitive tasks (Rayner 1978). The inclusion of eye movement analyses in these studies does not guarantee more generalizability of findings, but hopefully provides helpful insights into specific aspects of human memory and cognition.

The study of eye movement patterns as they pertain to cognitive processes has been directed along several different routes. For example, eye movement analysis has been applied to further our understanding of reading. Each domain, including the area of interest in this paper (eye movements applied to picture viewing), has benefited from eye movement research, particularly in view of recent technological advances enabling more accurate and reliable recording of data. Older studies often focused on eye movements in reading (e.g., Dearborn 1906; Tinker 1958), and sought information on variables such as saccadic suppression (Dodge 1900), duration from initiation of saccadic eye movement from a fixation point to a target at another location (Bartz 1967), variables correlating with saccadic latency (Miller 1969), and developmental changes in eye movements (Buswell 1922). Newer emphases on eye movements have involved, for example, comparison between speed readers and normal readers (McLaughlin 1969). In addition, an interesting and recent line of inquiry has postulated, and found considerable evidence that, the use of parafoveal and peripheral vision increases with reading skill (e.g., Nodine & Evans 1969; Nodine & Lang 1971).

As previously mentioned, a number of significant technological advances have been made, permitting a more systematic and reliable examination of eye movements. Consequently, eye movement studies have been directed to areas other than reading. An example involves the use of visual search tasks. In a visual search task, a subject either finds a particular target item in a visual display, or is asked if the item is present in a display. A number of relevant findings have been made; in particular, through a series of studies by Gould and his colleagues (Gould 1967; Gould & Dill 1969; Gould & Peeples 1970; Gould & Schaffer 1965, 1967). Some of the major findings reported were as follows: the more similar a pattern was to the target, the longer subjects looked at it. Subjects fixated longest on target patterns, and looked more directly at patterns which were more similar to the target pattern than less similar patterns. Mean fixation durations in these experiments were longer than is typical of fixation durations found in studies of eye movements and reading. Visual search tasks have also been manipulated in terms of visual characteristics of stimuli, i.e., color, shape, and location (Williams 1967; Luria & Strauss 1975). In these cases, manipulation of stimuli and task heavily influenced visual search factors, because the conditions inducing limited acuity and overreliance on peripheral vision made color a better cue than form.

Eye movement analysis has been applied to many other aspects of research, including pattern recognition, problem solving, and the study of language. While results within each of these areas may prove interesting, they are too far afield to warrant consideration here. The examples previously cited were intended to provide a few examples of current and past research utilizing eye movement analysis.

Eye Movements and Picture Viewing

Past studies of recognition memory for pictures using eye movement analysis support the contention that eye movement data reflect cognitive processes (Rayner 1978). Before reviewing the sparse literature on recognition memory for pictures and eye movements, brief mention will be given to somewhat related aspects of picture viewing: analysis of patterns of visual exploration and studies of peripheral vision.

Research involving analysis of patterns of visual exploration has been primarily directed toward addressing the question of whether or not subjects demonstrate a regular, sequential pattern of eye movements (a preferred scan path), and if so, whether or not memory performance correlates positively with the presence of a preferred scan path. It appears that preferred scan paths are used (Noton & Stark 1971; Parker 1978; Locher & Nodine 1974) but they do not necessarily contribute to accurate recognition (e.g., Furst 1971). Rather, results implicate the importance of parafoveal and peripheral vision (Parker 1977, 1978; Walker-Smith, Gale, & Findlay 1977).

Instead of a single, "preferred" scan path, evidence indicates the importance of peripheral vision in picture viewing. As early as 1935, Buswell discovered that a high frequency of eye fixations was directed toward "informative" objects. Mackworth and Morandi (1967) came to the same kind of conclusion, and furthermore, when it was found that the relative concentration of eye fixations did not vary over time, pointed out the importance of peripheral information, since subjects viewed pictures "efficiently" at once. Antes (1974), however, found that subjects first fixated on "informative" elements (as defined by independent raters), and over time, began to fixate more frequently on less informative elements. Longer exposure times, therefore, appeared to influence the location of the gaze, and also may influence the contribution of peripherally encoded information (Nelson & Loftus 1980). When presentation time is very brief, only informative objects will be scanned (Loftus & Bell 1975; Loftus & Mackworth 1978). Informative objects may be unexpected or unusual (Loftus & Mackworth 1978) or simply function as details which tend to distinguish the picture in some way (Loftus & Kallman 1979).

Eye Movements and Recognition Memory for Pictures

Studies of recognition memory for pictures with eye movement analysis are very scarce. However, the few that exist are relatively important. Loftus (1972) demonstrated that number of fixations (at input) was a positive function of memory performance, and, contrary to results of eye movement research outside memory for pictures, performance was independent of exposure time (when the number of fixations was held constant). Although Loftus did not monitor eye movements at test, according to his results one could tentatively infer that greater response accuracy may correlate with fewer fixations at test, but only for easily discriminable items. Since Loftus used easily discriminable items and found a direct correlation between the number of fixations at study and subsequent memory performance, fewer fixations at test may correspondingly predict increased memory. More fixations at study may lead to improved encoding, thus fewer fixations may be needed to recognize the "oldness" or "newness" of a test photograph.

For more difficult test items, different findings may be suggested. Tversky (1974), using line drawings which were relatively more difficult to discriminate, found that <u>fewer</u> fixations was the primary predictor of accurate memory (pictures with "many features in common" were used). This result is virtually the opposite of Loftus' (1972) finding. In another pertinent study (previously cited), Gould (1967) noted that both the number of fixations and fixation duration were greater for targets than for nontargets in a visual array, and for nontargets, the average duration increased as a function of the number of similar features the nontargets held in common with target photos. The general findings of Gould's (1967) study may prove illuminating, even though his study contained neither a long-term memory task nor pictures.

Besides these studies by Loftus (1972) and Tversky (1974), little research has been done on eye movements and picture memory. It is unfortunate that the available research has not been oriented toward examining some specific retrieval characteristics of memory (both of the above examined eye movements at study) at least in order to obtain measures of eye movement patterns more directly associated with decision processes leading to accurate recognition.

Consequently, drawing specific hypotheses for the present study on the basis of past eye movement research would likely prove hazardous. As already mentioned, a number of methodological differences exist, the most important being that past studies in picture memory tested eye movements at input, while the present study examines eye movements at test (thus the present study is exploratory). Again, as Rayner (1978) points out, differences in results may be linked simply to the use of different stimuli and materials (see also Tversky 1974). It is suspected that differences in difficulty of stimuli and differences in types of stimuli have led to different results in the Loftus (1972) and Tversky (1974) studies.

Statement of Problem

In spite of these problems and considerations, it is hoped that eye movement data will render insights and elaborations on factors involved in accurate recognition memory for pictures. Eye movement parameters ought to somehow reflect both decision difficulty and response accuracy; more specifically, it is possible that fixation durations and number of fixations will correlate with task difficulty. If this is the case, for example, those subjects who must discriminate between related items and lures should spend more time on, and/or demonstrate more fixations for, lures than subjects who consider both types of items "new." An analogous result may then occur between exact copies and related items. Accurate memory may correlate with fewer fixations and possibly with shorter average fixation durations.

As previously mentioned, a prominent study (Loftus 1972) has linked greater number of fixations with superior memory performance. However, in this study each viewer was attempting to <u>encode</u> when eye movements were recorded. No relevant information has been gathered concerning eye movements when subjects attempt to <u>retrieve</u> information. Thus, these predictions dealing with eye movements must remain tentative, and are at best based on general principles.

On the other hand, more specific predictions may be made concerning memory performance. Before elaborating on this point, however, the issue of "relatedness" of test items must first be addressed.

A critical issue for this study involves the nature of a similar or "related" item involved in the test. There are many possible types of related items. For example, one may select black and white copies of color photos as related items. The most important issue involves the assurance that a related item and the corresponding "exact copy" (input photograph) share certain similarities along at least some dimensions, e.g., the two should contain some similar objects, and/or light-dark shades, photograph angles, colors, texture, and so on. These similarities may in some cases be easily quantifiable (Bartlett, Till, & Levy 1980) but need only represent dimensions to which people can be sensitive.

The two types of related items used in the present study are "mates" and "reversals," respectively. A mate is the other member of the same parent photograph as its partner on the input list, i.e., the input photo and its mate are two non-overlapping halves of a single photograph. A reversal is a left/right change in orientation of an input list photo, and consequently would seem to share virtually all features in common with its input counterpart. The difference between a reversal and its partner may be more purely nonverbal than between a mate and its partner (Bartlett, Till, & Levy 1980).

How accurately can a reversed photograph at test be discriminated from its counterpart at input? How accurately are new photographs discriminated from related photos? The inclusion of these two types of related items ought to provide for interesting comparisons between and within Resemblance and Discrimination test conditions. If mates and reversals vary in terms of visual similarity to input list photographs, the types of test (Resemblance or Discrimination) may vary in difficulty. For example, reversals may be more difficult as related items in the Discrimination test condition, while mates may be more difficult in the Resemblance test condition.

Verbally similar items tend to be more difficult to discriminate than verbally dissimilar photos (Bartlett, Till, & Levy 1980). Verbal distinctions aside, accurate recognition should be based on the uniquely familiar or unfamiliar impressions a photograph imparts. This hypothesis should hold for both types of related items, and in the case of reversals, as mentioned above, discriminating from an input photo may be more difficult since reversals are visually and verbally nearly identical to input photos. In fact, this result has been demonstrated previously (Bartlett, Till, & Levy 1980). Although subjects were divided into "verbalization" and "draw" test groups (and both of these groups were further divided into Resemblance and Discrimination test conditions), discrimination scores (A') from both groups indicated a marked difficulty in discriminating reversals from exact copies (discrimination condition); and conversely, relative ease in classifying reversals as "old" under Resemblance test instructions.

Considering only mates (regardless of verbalization or draw task instructions) one might also expect that, since mates share certain features in common with exact copies, it might be somewhat easier to label a mate "old" than "new" (although not nearly as easily as with reversals). Thus the "visual distance" between a new photo (lure) and reversal may be greater than that between a lure and a mate. Recognizing a reversal as old may be easier than recognizing a mate as old, but calling a mate "new" may be easier than calling a reversal "new."

The present study, then, manipulated test task (Resemblance or Discrimination) and test composition (same photos, mates, and lures, or same photos, reversals, and lures). Eye movements were monitored at test. In summary, it is predicted that accuracy of recognition memory will vary according to a test type x test composition interaction. It is believed that memory will be best in the Resemblance/Reversal condition but worst in the Discrimination/Reversal condition, since these conditions seem to represent furthest and closest visual distances to input list photos, respectively. Although further predictions about eye movements remain tentative, the number of fixations may correlate with memory and also with item difficulty. The inclusion of eye movement analysis is, in part, for exploratory purposes.

CHAPTER III

METHOD

Subjects

The subjects were 48 undergraduate students enrolled at the University of North Dakota who received course credit for participation. All subjects were tested individually and reported normal vision without correction. Half of the subjects were assigned to the Resemblance test condition and half were assigned to the Discrimination test condition; at test, half of each group viewed reversals and half viewed mates as related items. The proportion of males in each of the test conditions was approximately equal. All subjects were administered the final 20 items of the Wechsler Adult Intelligence Scale-Revised (Wechsler 1981) vocabulary subtest prior to the experiment.

Apparatus

A Kodak Carousel projector was used to display stimuli on a screen positioned approximately five feet in front of the subject, and the pictures subtended a visual angle of approximately 19 degrees (horizontal) X 28 degrees (vertical). The projector was equipped with a Gerbrands tachistoscopic shutter which controlled exposure time. During the recognition test, exposure of each slide was terminated and the corresponding eye movement recorded when the subject pressed a response key situated before him/her. Eye movements were monitored by a Gulf and Western Eye View Monitor. The monitor used the relative location of the center of the pupil and reflection of an infrared light from the cornea to determine eye position. Data were output 60 times per second as an X-coordinate and Y-coordinate of eye position. The analog outputs were digitized by a PDP 11/34 minicomputer and stored on floppy discs. Later the data were reduced to fixations and fixation durations using a program described by Kleigl and Olson (1981).

Materials

The stimuli were drawn from a pool of 115 pairs of 35 mm scenic, color slides of landscapes and cityscapes taken from magazines. The slide pairs consisted of two non-overlapping pictures from the same parent photograph, and were visually similar to each other. There was a single input list for all subjects, composed as follows: one member from each of 58 pairs served as an input list item. Because of time constraints, memory was examined for only 24 of these items in the subsequent recognition phase for a given subject: half of these were represented at test by target photos(Same Photo) and half were represented by Related items. The remainder of the items in the input list served as filler items, including five fillers placed at the beginning of the input list and five at the end. Excepting these ten, the input list was randomly arranged. For counterbalancing purposes, half of the subjects viewed the input list in reverse order.

Two sets of 36 stimuli were used at test. Half of the subjects viewed one set (Test A) and half viewed the other set (Test B). Thus, Test A subjects were tested on their memory for one set of 24 input items, and 12 "lures," while Test B subjects were tested on another set of 24 input items and 12 lures. Each set was therefore composed of 12 target photos (exact copies of input items), 12 related items, and 12 lures.

Depending on test composition, each subject viewed either "mates" or "reversals" as related items. Each mate was the other member of the same parent photograph as its partner on the input list. A reversal was a left/right change in orientation of an input list photo.

Procedure

All subjects were tested individually. After being seated and given a general orientation to the experiment, the final 20 items of the WAIS-R vocabulary subtest were administered, with subjects writing out their responses. Subjects were randomly assigned to either the Resemblance or Discrimination test condition, and within each group, to either the reversal or mate condition. In addition, each subject was randomly assigned to view either Test A or Test B.

Each subject was instructed to study each input slide for its two second duration, and an eight second interstimulus interval followed each slide. Subjects were informed of a memory test to follow presentation of the input list, but no further details were provided.

Following presentation of the input list, eye movement equipment was calibrated and a recording of the calibration made by having the subject fixate nine points (a 3 X 3 array) covering the extremes of the visual field of the pictures. Each subject was given test instructions, the exact instructions contingent on which of the four test task x test composition conditions was assigned. Subjects in the "Discrimination/Reversals" condition were instructed to reject new slides (lures, not shown at input), and also to reject left/right reversals of input slides (consider them "new"). They were told to accept as old only "exact copies." Subjects in the "Resemblance/Reversals" condition accepted (considered "old") exact copies and reversals, and rejected (considered "new") lures. Using mates as related items, subjects in the "Discrimination/Mates" condition were instructed to accept only exact copies, and reject both related items (mates) and lures. Finally, subjects in the "Resemblance/Mates" condition optimally accepted exact copies and mates, and rejected lures.

To facilitate these instructions, a practice run with four sample input pictures (not seen previously) and 12 sample test items was given prior to the actual recognition test. Subjects in each of the four conditions were thus instructed during the practice test about which types of pictures to accept and which to reject. The practice run was repeated, if necessary, so that by the final sample input item each subject correctly identified which types of photos were "old" and which were "new."

Final instructions emphasized accuracy over speed. Subjects were told to fixate on a small mark at the center of the visual field upon being given the warning cue "Ready." The test item followed immediately. Subjects were told they had up to 10 seconds to respond to the test item with a key press, and the key press automatically terminated the stimulus presentation and eye movement recording. Following each key press, subjects reported aloud their recognition response (old or new) and the response was recorded by the experimenter. Test items were presented at approximately a 15 second rate.

CHAPTER IV

RESULTS

Memory Performance

Table 1 contains the proportion of "old" responses as a function of test task and item type. The proportions clearly show the flexibility seen previously in Bartlett, Till, and Levy (1980). Despite some degree of criterion shift (i.e., all proportions are higher under resemblance task instructions), there are striking differences in the proportion "old" responses for related items depending on the test instructions. Apparently, subjects have knowledge of the "similar-but-different" quality of these related items and use this as needed in a resemblance or discrimination test. The degree of flexibility appears equal for mates or reversals used as related items.

In order to obtain a more sensitive measure of recognition accuracy and to eliminate potential criterion level explanations of differences between tests, the data were analyzed with the framework of signal detection theory (Kintsch 1969; Grier 1971). Accuracy scores (A') were computed for each subject based on hit rates and false alarm rates. Perfect performance would be represented by

Table 1. Mean Proportion and Standard Deviations of "Old" Responses as a Function of Test, Test Composition, and Item Type

Test Task		Test Composition					
		Test with Mates			Test with Reversals		
		Same Photo	Related	Lure	Same Photo	Related	Lure
Resemblance	Mean	.910	.639	.146	.861	.840	.104
	SD	.105	.142	.091	.157	.154	.084
Discrimination	Mean	.750	.167	.035	.840	.410	.049
	SD	.163	.083	.093	.115	.142	.080

a score of 1.0, and chance performance by a score of .50. The A' scores, for both resemblance and discrimination conditions, were based on responses to two rather than all three types of test item. In the resemblance test condition, "hits" were made by calling related items old, and false alarms occurred when lures were called old. In the discrimination test condition, hits occurred when subjects called same photos old, and false alarms were made in calling related items old. Thus, accuracy scores reflected either resemblance information or discrimination information, but not both. That is, resemblance subjects saying "old" to a related item but "new" to a lure do so on the strength of the similarity or resemblance to an input picture. Since neither is an exact copy, there is no advantage that one was seen before. Similarly, discrimination subjects saying old to a same photo item and new to a related item do so based on which one has been seen before, even though both are familiar (that is, resemble a prior experience).

The A' proportions are presented in Table 2. The highest level of performance achieved was in the Resemblance/Reversal condition, and worst performance occurred in the Discrimination/Reversal condition. A two-way analysis of variance performed on the A' scores following arcsine transformation indicated a significant interaction of test task x test composition, $\underline{F}(1,44)$ =

Table 2. Mean Accuracy Proportions (A') and Standard Deviations as a Function of Test Task and Test Composition

Test Task		Test Composition	
		Test with Mates	Test with Reversals
Resemblance	Mean	.831	.920
	SD	.086	.071
Discrimination	Mean	.858	.799
	SD	.105	.106

9.71, $p < .01$, MSe = .19. No significant main effects were observed, although the effect of test type approached significance ($p < .06$). Further analysis performed on the interaction disclosed a simple main effect of test composition in the resemblance test condition, i.e., performance was significantly poorer in the Resemblance/Mate condition in comparison to the Resemblance/Reversal condition, $F(1,22) = 8.702$, $p < .01$, MSe = .19. A simple main effect was also observed as a function of test task with reversals. Performance in the Resemblance/Reversal condition was significantly better than in the Discrimination/Reversal condition, $F(1,22) = 12.497$, $p < .01$, MSe = .19. It appears that the observed interaction is primarily due to the high level of performance occurring in the Resemblance/Reversal condition.

Vocabulary Test Results

As mentioned previously, to obtain an index of verbal ability, the final 20 items of the WAIS-R were administered before presentation of the input list. Prior experiments (e.g., Bartlett, Till, & Levy 1980) have indicated that verbal encoding may facilitate recognition in some types of memory tests. Although no encoding task was employed in the present study, it is possible that the nature of certain stimuli (i.e., photographs with easily verbalizable details) may allow verbal skill to contribute to memory performance. In order to explore this possibility, a two-way analysis of variance was performed on the vocabulary scores for the four groups. Mean proportions correct for the four groups were: .462 (Resemblance/Mate), .475 (Resemblance/Reversal), .448 (Discrimination/Mate), and .471 (Discrimination/Reversal). Results, both for main effects and interaction, were not significantly different (all with $p > .5$). No confound of verbal skill was present.

An interesting result occurred, however, in correlational analyses of proportion correct in recognition and vocabulary scores. "Proportion correct" scores (not to be confused with A' scores) are simply single proportions based on accurate responses to all three item types. In the Resemblance/Mate condition, subjects' performances on the memory test and the vocabulary test were highly correlated ($\underline{r} = .60$, $p < .05$) meaning that verbal skill accompanied accurate test performance. Correlations in the Discrimination test conditions (for both mates and reversals), as well as in the Resemblance/Reversal test condition, were not significant ($\underline{r}$ = .10, .17, and .28, respectively). (Similar correlations were found in the four conditions upon examination of A' scores, although all correlations fell short of the $p < .05$ level.) The two highest correlations occurred in the Resemblance test conditions. This result seems to be in line with previous research indicating verbalization effects with resemblance tests using mates (Bartlett, Till, & Levy 1980). Reversals represent a more purely "visual" transformation of same photo items, and are thus less susceptible to verbalization or verbal skill effects, in comparison to mates.

Eye Movement Analyses

Eye movement data were collected at test. Due to occasional equipment problems beyond the experimenter's control, a small amount of the eye movement data was lost (approximately 7%). However, the loss of these data was not related systematically to any of the variables under study. Up to 10 seconds was allowed for subjects to make a yes/no decision by pressing a key. Each trial, therefore, contained from about one to ten seconds of eye movement data. Total response times were not analyzed by item, but total fixation time (excluding time of saccadic eye movements) averaged approximately three seconds.

The primary indexes of interest in this study were number of fixations and fixation durations (Loftus 1972; Tversky 1974). For each subject, the median number of fixations and the median fixation durations were calculated for same photo items, for related items, and for lures. The data are presented in Table 3. Analysis of variance was three-way (test x composition x item). A main effect of item was found in examination of the mean number of fixations, $\underline{F}(2,88) = 10.38$, $p < .001$, $MSe = 6.55$. A

Table 3. Mean of Median Number of Fixations, Mean of Median Fixation Durations, and Standard Deviations as a Function of Test, Test Composition, and Item Type

			Test Composition			
			Test with Mates		Test with Reversals	
Test Task	Item Type		Fixations	Duration (msec)	Fixations	Duration (msec)
Resemblance	Same Photos	Mean	7.12	300.9	8.92	294.9
		SD	4.20	29.8	3.84	37.5
	Relateds	Mean	10.75	286.8	9.00	296.8
		SD	4.58	35.3	5.64	43.0
	Lures	Mean	12.96	283.1	11.88	276.8
		SD	5.78	29.5	5.57	34.4
Discrimination	Same Photos	Mean	9.12	271.8	8.58	288.7
		SD	3.89	29.8	3.01	34.6
	Relateds	Mean	11.12	272.4	9.79	284.0
		SD	4.26	29.4	4.41	29.6
	Lures	Mean	9.83	265.5	8.20	270.9
		SD	3.53	33.3	3.12	32.5

significant interaction of test x item was found for number of fixations, F(2,88) = 10.314, $p < .001$, MSe = 6.55. The interaction is displayed in Figure 1. Collapsing across test composition, further analysis disclosed a significant simple main effect for items in the Resemblance test condition ($p < .001$) but not in the Discrimination test condition ($p > .10$). Between the two tests, a simple main effect was observed for lures ($p < .001$) but no simple effect was found in analysis of same photos and relateds. Using the Newman-Keuls procedure for comparing the differences between means, it was determined that significantly more fixations were given on lures compared to same photo items ($p < .01$), but only in the resemblance test condition. In this test condition, the number of fixations on relateds was not significantly different from the number of fixations on either same photos or lures. In the discrimination test condition, no signficant differences were observed in comparisons of the number of fixations between the three types of items.

In terms of fixation durations, a three-way analysis of variance (test x composition x item) revealed a significant main effect of item, F(2,88) = 14,689, $p < .001$, MSe = 196.960. Further analysis (using the Newman-Keuls procedure) revealed a significant difference in fixation duration between lures and both related and same-photo items ($p < .05$ for both comparisons). No significant

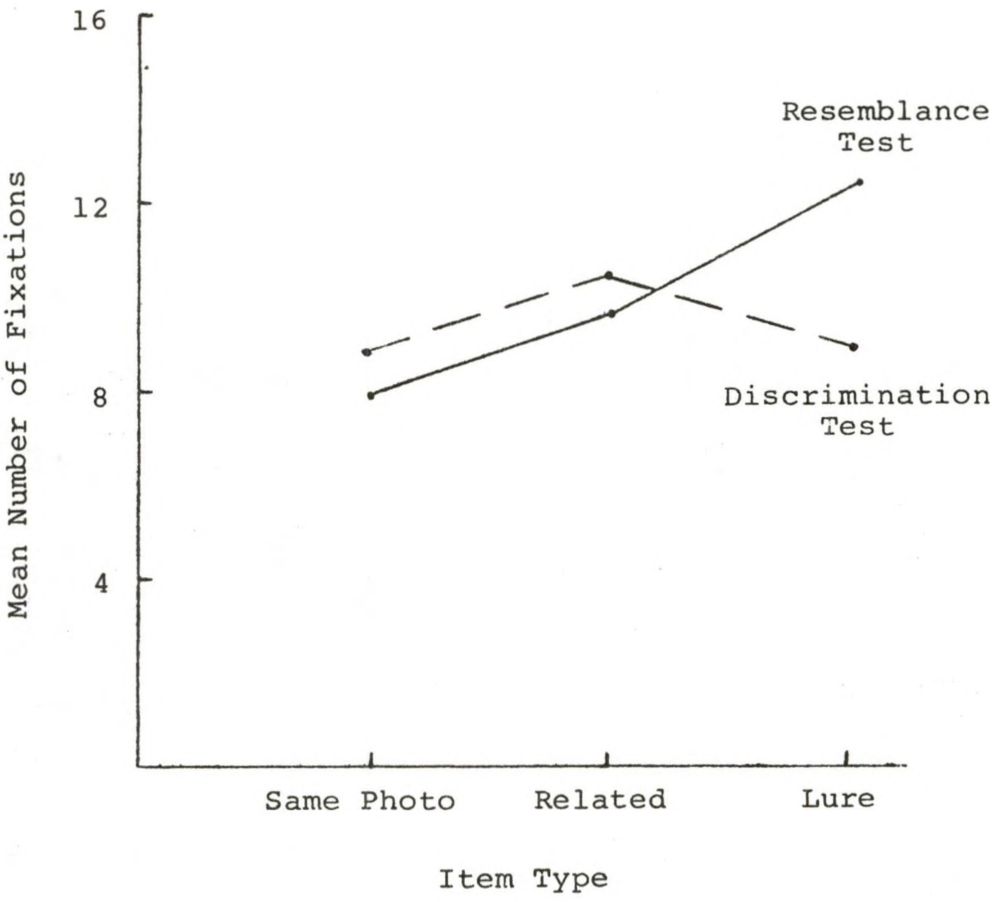

Figure 1. Mean Number of Fixations as a Function of Test and Item Type

difference was noted between same photo and related items. In terms of both number of fixations and fixation duration, then, lures were examined with more rapid eye movements than either same photos or related items.

Correct/Incorrect Responses and Eye Movements

Further analysis of eye movement data was directed toward the examination of correct vs. incorrect responses in order to detect different viewing patterns based on test composition difficulty. The test items used previously in computing "hits" and "false alarms" were included in the analysis, and subjects who made either no hits or no false alarms were excluded, thus reducing the number of units of analysis to 36. For each subject, the median number of fixations and the median fixation duration were calculated. Calculations were done separately for test items correctly and incorrectly called "old" or "new," for the two kinds of test item used in the recognition analysis (e.g., same-photo and related items for Discrimination test condition subjects). The data are contained in Tables 4 (fixations) and 5 (durations).

Results of a four-way analysis of variance (test x composition x item x correctness) revealed a main effect of correctness on number of fixations, $\underline{F}(1,32) = 29.281$, $p < .001$, $MSe = 19.412$. Incorrect responses ("false alarms" and "misses") were accompanied by significantly

Table 4. Mean Number of Fixations on Correctly and Incorrectly Identified Photographs as a Function of Test, Test Composition, and Item Type

Test Composition		Test Task			
		Resemblance		Discrimination	
Test with Mates		Correct	Incorrect	Correct	Incorrect
Same Photos	Mean	a	a	9.00	13.75
	SD			4.43	5.26
Relateds	Mean	10.75	13.62	10.46	15.00
	SD	4.49	7.00	3.71	9.31
Lures	Mean	12.71	15.90	a	a
	SD	5.52	6.99		
Test with Reversals					
Same Photos	Mean	a	a	8.04	11.85
	SD			2.59	3.96
Relateds	Mean	8.00	14.43	8.17	10.50
	SD	2.36	6.99	1.80	4.60
Lures	Mean	11.58	15.57	a	a
	SD	5.22	7.25		

[a] Only the test items used in computing "hits" and "false alarms" were included in the analysis.

Table 5. Mean Fixation Durations (in msec) on Correctly and Incorrectly Identified Photographs as a Function of Test, Test Composition, and Item Type

Test Composition		Test Task			
		Resemblance		Discrimination	
Test with Mates		Correct	Incorrect	Correct	Incorrect
Same Photos	Mean	a	a	269.4	323.5
	SD			28.6	66.1
Relateds	Mean	293.1	291.0	272.1	269.3
	SD	37.6	44.3	33.6	26.5
Lures	Mean	284.4	302.3	a	a
	SD	30.4	43.7		
Test with Reversals					
Same Photos	Mean	a	a	291.3	300.5
	SD			41.4	38.0
Relateds	Mean	306.7	280.9	296.7	285.9
	SD	47.0	35.7	52.0	25.4
Lures	Mean	275.9	311.2	a	a
	SD	34.7	52.7		

[a]Only the test items used in computing "hits" and "false alarms" were included in the analysis.

more fixations than were correct responses ("hits" and "correct rejections"). In the fixations analysis, no other effects were found. No significant effects were found in a similar four-way analysis of variance of fixation duration data, with the exception of a three-way interaction of test x correctness x item, $\underline{F}(1,32) = 5.135$, $p < .05$, MSe = 7548.2. In exploring the interaction further, four $\underline{t}$ tests were done (after collapsing over test composition), on correct vs. incorrect test items. Relateds and lures served as hit and false alarm test items in the Resemblance test condition, respectively; exact copies and relateds, respectively, served as hit and false alarm items in the Discrimination test condition. No significant results were observed (each result with $p > .05$). The three way interaction is difficult to account for, but may be partly described this way: in the Resemblance test condition, "old" responses to relateds involved somewhat long durations, "new" responses to lures involved shorter durations, and incorrect responses show the opposite pattern (but not to a great degree). In the discrimination condition, no clear pattern emerges.

Correlational Analyses

Scores on dependent variables for each subject, including A' accuracy, simple "proportion correct" (alluded to earlier), vocabulary score, number of fixations for each item type, and average fixation duration for each item type, were subjected to correlational analyses across the four groups and within each group. The data are contained in Table 6, Appendix A. Trends found in the analyses across all four groups included very high correlations between item types for both number of fixations and fixation durations (all $p < .0001$), e.g., number of fixations for same photo items correlated very highly with fixations for related items and lures. No significant correlations were observed between number of fixations and fixation durations. The same result was found, with virtually no exceptions, in separate correlational analyses of the four groups. Thus, for example, subjects with more fixations did not have shorter average duration times for a particular item type.

Other results of the overall correlational analyses were significant negative correlations between the following: (1) the number of fixations on same photo items and simple proportion correct; (2) the number of fixations on same photo items and A' scores; (3) the number of fixations on related items and simple proportion correct; and (4) the number of fixations on related items and A' scores. Significant levels were: $p < .01$ for same photo/proportion correct, and $p < .05$ for the three others. In other words, greater fixations for these two items varied inversely with memory accuracy. Interestingly, no such finding was present in the case of lures ($p > .3$ for accuracy and A'). A possible explanation could be that accurate recognition of same photo and related items was accompanied by fast responses (and consequently fewer fixations) while accurate recognition of lures was less instant. Perhaps a response style oriented toward determining common characteristics of the test photo (found in exact copies and related) instead of looking for different characteristics was more frequently taken. An emphasis may have been placed on the issue of "old," compared to "new."

A final result was that proportion correct correlated strongly ($p < .0001$) with A' throughout all four cells. The usefulness of A' in refining but paralleling actual "proportion correct" data should be evident.

Broken down by test type and test composition, several additional findings are noteworthy. Intercorrelations are presented in Appendix A, Table 7 (Resemblance/Mate test condition), Table 8 (Resemblance/Reversal), Table 9 (Discrimination/Mate) and Table 10 (Discrimination/Reversal). As previously mentioned, in the Resemblance/Mate condition vocabulary scores correlated significantly with memory accuracy ($p < .04$). Over all groups, a marginal result was discovered linking vocabulary and proportion correct ($p < .10$). Vocabulary did not correlate with A' scores in any case. Regarding the difference between A' and proportion correct, those subjects who did well on the vocabulary test likely made proportionately fewer mistakes on the items excluded from the A' analyses, while those subjects who did not do well on the vocabulary test made proportionately more mistakes on the items excluded from the A' analyses (Resemblance condition exact copies and Discrimination condition lures).

Correlations between item types for number of fixations and fixation durations were evident for each individual test group.

Accuracy correlated negatively with number of fixations for same photos in the Resemblance/Reversal condition ($p < .03$) and the Discrimination/Mate condition ($p < .01$), but not in the Resemblance/Mate condition ($p > .6$) or the Discrimination/Reversal condition ($p > .4$). The two significant correlations occurred in the two relatively easier memory tests, while lower (not significant) correlations occurred in the more difficult memory tests.

Interestingly, although an overall significant correlation was found between accuracy and fixations on related photographs, none of the separate group results was significant. The trend, however, is very similar to the correlation between accuracy and fixations on exact copies, and may be further evidence that the Resemblance/Mate and Discrimination/Reversal tasks are the more difficult.

In the case of lures, only in one condition (Discrimination/Mate) was a significant correlation (negative) observed between A' proportion and lures, and between proportion correct and lures, $p < .03$. Again, in both discrimination conditions a lure would be fairly easy to reject (call "new"), and may be accompanied by fewer fixations.

CHAPTER V

DISCUSSION

The present study replicates previous results (Bartlett, Till, & Levy 1980), and provides empirical support for exploration of human memory differences employing manipulations of test difficulty. Specifically, subjects show flexibility in their ability to use two kinds of information about related items (i.e., knowledge of resemblance and knowledge of differences). The previously cited study employed "verbalization" and "draw" tasks at input, with recognition memory for "reversals" subject to not only effects of orienting task but also to effects of test type. The present study, without the use of a task affecting encoding, found a similar difference in memory accuracy. For reversals, memory was distinctly superior in the resemblance test condition in comparison to the discrimination test condition. Further, superior recognition in the resemblance condition was reversed when "mates" were used, e.g., it was easier for subjects to call mates "new" than "old." The occurrence of this interaction draws attention to how retrieval processes may be differently affected in certain test situations, independent of input variables. Without adequate cues (i.e., either exactly the same or completely different test photos compared to input photos), memory deficits will likely occur. The degree of visual similarity between an input photo and a test photo may either aid or hinder accurate recognition. This difference cannot be attributed to varying levels of verbal skill in the groups or to choice of a particular kind of related distractor. The flexibility seen here supports results of previous work (e.g., Bartlett, Till, & Levy 1980; Kintsch 1970) and demonstrates that resemblance and discrimination tasks can be performed effectively with different kinds of "similar but different" items in the test.

Eye Movement Indices

The inclusion of eye movement analyses in this experiment was intended to address two issues: (1) whether subjects scan test photographs differently as a function of test task and distractor similarity, and (2) whether eye movement patterns are different between correct and incorrect responses. Unfortunately, prior research in recognition memory examined eye movements at input (Loftus 1972; Tversky 1974) and should not be generalized to this study. Gould's work (e.g., Gould 1967; Gould & Dill 1969) cannot be generalized either, since his stimuli (visual arrays) and task (locating a target amongst distractors) were dissimilar from those of the present study. Despite these factors, the conclusion of Just and Carpenter (1976) that memory for pictures reports a lack of correlation between fixation duration and performance, is tentatively supported or at least not refuted. Strong support cannot be given since this conclusion was based on eye movement recordings at study, not at test. Fixation durations did not significantly vary with accurate test performance. In the present study, however, there was a strong main effect of item, regardless of memory performance. Longest durations were for exact copies, relateds, and lures, in that order. This result is not explainable in terms of similar prior results, since no previous research has been done in this area. The result, however, should not draw attention to durations as a correlate of memory, since no clear effect of duration was seen for correct vs. incorrect items in any of the test task and test composition groups. Stimulus characteristics alone may arguably provide a reasonable explanation. A possible rationale is that "new" photographs may be scanned with shorter fixation durations, as a matter of course, compared to previously seen photos. Antes (1974) found that pictures were quickly scanned for "most informative" features initially, then the pictures were scanned more slowly over time (on less informative features). The result here may be somewhat analogous, but viewing and test are separated by a lag (viewing occurred on two separate occasions in the present study, at input and test). Exact copies may have been scanned more slowly at test (presumably having been scanned more quickly earlier). Each test photograph, then, may be scanned according to its familiarity. Familiar photos, having presumably been rapidly scanned at input, are viewed with relatively longer fixation durations at test. New photos, not having been seen at study, may be quickly scanned for most informative features.

Likewise, in also considering the number of fixations, new photos may have received more fixations and shorter duration times on the basis of "newness." To support a "novelty" factor influencing the results, if novelty was an overriding or even important factor, differences in the number of fixations on lures should not have occurred between the two tests. Indeed, in the Resemblance test condition, where lures served as effective "false alarm candidates" and were difficult to discriminate from relateds (mates much more so than reversals), subjects apparently scanned lures more, not on the basis of newness, but because lures were difficult test items. Less difficulty was encountered in the discrimination conditions where the "visual distance" gap (between "old" items and lures) was significantly wider. Hence, fewer fixations occurred for lures in the discrimination condition. Thus, the simple "novelty" hypothesis cannot account for the clear difference between number of fixations on lures in the two test conditions. It is possible that the novelty of a photograph may influence the manner in which it is viewed, that is, with varying fixation duration times (Antes 1974) but the demands of the test may override this effect. Difficulty of test item may have largely contributed to why eye movement results varied across item. Unfortunately, in terms of fixation durations, no clear pattern emerges favoring item-type difficulty over novelty, or vice-versa.

Numbers of fixations, unlike fixation durations, were significantly different depending on memory accuracy. (An item effect was also present.) Since the difference is so marked, it appears that subjects either recognized test photos at once or not at all (with rare exceptions). The plausible hypothesis that more fixations at test may contribute to memory was not borne out. If it is assumed that the number of fixations varies directly with response time, this study replicates to some extent results of a previous one (Bartlett, Till, & Levy 1980), comparing fast and slow responses. Finally, although procedural differences exist between the present study and prior research in eye movements and picture memory, results support the findings of Loftus (1972) in that number of fixations was the most important eye movement index correlating with memory.

Comments on Two Types of Information in Memory

Despite its speculative basis, a brief discussion may be addressed to how accurate performance in each of the test groups in this study may be determined according to two somewhat different retrieval processes. More specifically, the relative contributions of "verbal" and "general visual" memory may differ according to test type and test composition. This question has been addressed before, but from a slightly different perspective (Bartlett, Till, & Levy 1980). In that study, a verbal encoding task led to better retrieval (than did a nonverbal task) in the resemblance test condition but not in the discrimination test condition. In the discrimination test condition, verbalization at input was ineffective in improving subsequent memory performance, but distinct improvement was noted in the resemblance condition. Although the present study seeks to examine retrieval processes in recognition through eye movement analyses and contains no encoding manipulations, the results raise several questions which may be addressed within this "dual memory code" framework.

Present results provide further indications that performance may be subject to verbal skill factors, i.e., accurate performance in the Resemblance/Mate task correlated with verbal skill. One may generalize in this case that the "payoff" is greater with verbal encoding compared to general visual encoding. On the other hand, verbal encoding may be ineffective (regarding retrieval) in the Discrimination/Reversal condition (Bartlett, Till, & Levy 1980). In other research, improved recognition has been directly associated with the encoding of "detail" or verbal information. While encoding details may be a generally superior way of improving subsequent memory accuracy, on some occasions this advantage may be removed (as in the Discrimination/Reversal condition) since reversals contain the same details as their same-photo partners. Thus encoding general visual information may at times prove to be beneficial.

A prior study made the misleading claim that "verbal" information was most relevant in recall tasks, and "visual" information was used in recognition tasks (Bahrick & Boucher 1968). Most recent studies may have somewhat overemphasized the relative contribution of verbal (detail) encoding in recognition: not only is verbal information relevant only to the extent of its distinctiveness (i.e., as the distinctiveness of a detail affects memory--Loftus & Kallman 1979), it is also limited or even clouded when test items which must be discriminated from input photos contain similar details. In the case of mates which must be discriminated from their input counterparts (the Discrimination/Mate condition), a situation akin to the Discrimination/Reversal condition may occur: the encoding of details at input may lead to incorrect judgment of mates if these details overlap with details examined on the test photograph. The encoding of specific details, then, seems to aid performance in some cases (Resemblance/Mate and Resemblance/Reversal) and hinders or does not aid performance in others (Discrimination/Reversal and Discrimination/Mate).

A final implication may be that the "superiority" of verbal or detail processing has been overstated. "Verbal encoding" may not even occur in some situations, or at the very least, overreliance on verbal memory stores may prove an ineffective strategy in retrieval. A more circumspect notion may be that the concept of dual memory codes is too simplistic: the usefulness of verbal or visual codes may depend heavily on the similarity of distractor items and the test's relative emphasis on similar features (Resemblance task) or dissimilar features (Discrimination task). As pointed out by Bartlett, Till, and Levy (1980), subjects may somehow "control the relative weights given to verbal and nonverbal information in making their recognition responses" (p. 446). A grave error may ensue in conceptualizing the codes as separate.

Conclusions

In conclusion, a number of interesting results were observed in this study. General results emphasize the importance of "retrieval" variables and how they influence accuracy of recognition memory for pictures. More specifically, test task interacted with levels of test composition in determining memory performance. Eye movement data were helpful in providing additional information about the nature of accurate retrieval: fixation patterns varied depending on the type of test items and in which test the item-type was used. The complexity of the processes involved in human memory has been underscored by the present results. It is hoped that research will continue to be broadened through experimentation in this domain.

APPENDICES

APPENDIX A

INTERCORRELATIONS OF SUBJECTS' SCORES ON DEPENDENT MEASURES

Table 6. Overall Intercorrelations of Subjects' Scores on Dependent Measures

	1	2	3	4	5	6	7	8	9
1. Proportion Correct	1	.93**	.24	-.38**	-.29*	-.13	-.03	-.19	-.13
2. A' Proportions		1	.17	-.29*	-.28*	-.06	-.07	-.21	-.18
3. Vocabulary Proportions			1	-.08	.03	-.02	.11	.09	.03
4. Fixations-Same Photos				1	.69**	.55**	-.09	.07	.00
5. Fixations-Relateds					1	.58**	.08	-.03	.10
6. Fixations-Lures						1	.06	.09	.14
7. Durations-Same Photos							1	.84**	.81**
8. Durations-Relateds								1	.86**
9. Durations-Lures									1

*p < .05
**p < .01

Table 7. Intercorrelations of Subjects' Scores on Dependent Measures in the Resemblance/Mate Test Condition

	1	2	3	4	5	6	7	8	9
1. Proportion Correct	1	.91**	.60*	.14	.08	.25	-.25	-.53	-.05
2. A' Proportions		1	.44	.13	.06	.25	-.40	-.60*	-.18
3. Vocabulary Proportions			1	.20	-.06	.20	.07	-.05	.33
4. Fixations-Same Photos				1	.73**	.40	-.36	-.39	-.36
5. Fixations-Relateds					1	.52	-.25	-.36	-.24
6. Fixations-Lures						1	.05	.06	.22
7. Durations-Same Photos							1	.89**	.81**
8. Durations-Relateds								1	.79**
9. Durations-Lures									1

*p < .05
**p < .01

Table 8. Intercorrelations of Subjects' Scores on Dependent Measures in the Resemblance/Reversal Test Condition

	1	2	3	4	5	6	7	8	9
1. Proportion Correct	1	.96**	.28	-.63*	-.55	.16	-.36	.50	-.47
2. A' Proportions		1	.20	-.58*	-.57	-.17	-.36	-.47	-.48
3. Vocabulary Proportions			1	.68**	-.57	-.60*	-.37	-.39	-.29
4. Fixations-Same Photos				1	.92**	.75**	.47	.57	.40
5. Fixations-Relateds					1	.79**	.23	.29	.14
6. Fixations-Lures						1	.15	.17	.08
7. Durations-Same Photos							1	.95**	.94**
8. Durations-Relateds								1	.94**
9. Durations-Lures									1

*p < .05
**p < .01

Table 9. Intercorrelations of Subjects' Scores on Dependent Measures in the Discrimination/Mate Test Condition

	1	2	3	4	5	6	7	8	9
1. Proportion Correct	1	.99**	.10	-.76**	-.41	-.64*	.48	.33	.43
2. A' Proportions		1	.06	-.76**	-.39	-.63*	.43	.27	.38
3. Vocabulary Proportions			1	.20	.15	.18	.20	.30	.22
4. Fixations-Same Photos				1	.64*	.93**	-.19	-.12	-.14
5. Fixations-Relateds					1	.80**	-.06	.13	.02
6. Fixations-Lures						1	-.13	-.03	-.09
7. Durations-Same Photos							1	.88**	.90**
8. Durations-Relateds								1	.93**
9. Durations-Lures									1

*p < .05
**p < .01

Table 10. Intercorrelations of Subjects' Scores on Dependent Measures in the Discrimination/Reversal Test Condition

	1	2	3	4	5	6	7	8	9
1. Proportion Correct	1	.97**	.17	-.25	-.21	-.30	-.11	-.37	-.60*
2. A' Proportions		1	.13	-.33	-.32	-.34	-.12	-.46	-.68*
3. Vocabulary Proportions			1	.53	.53	.46	.40	-.22	-.14
4. Fixations-Same Photos				1	.75**	.72**	.22	.26	.30
5. Fixations-Relateds					1	.66*	-.10	.07	.17
6. Fixations-Lures						1	-.32	-.17	.11
7. Durations-Same Photos							1	.65*	.56
8. Durations-Relateds								1	.83**
9. Durations-Lures									1

*p < .05
**p < .01

APPENDIX B

ANALYSIS OF VARIANCE SUMMARY TABLES FOR

DEPENDENT MEASURES

Table 11. Test by Test Composition Analysis of Variance Summary: Proportion Correct Recognition Responses

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	.03	.03	1.57
Test Composition (TC)	1	.02	.02	1.15
T X TC	1	.07	.07	3.31
Error	44	.88	.02	-
Total	47	1.00		

Table 12. Test by Test Composition Analysis of Variance Summary: A' Proportions

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	.07	.07	3.92
Test Composition (TC)	1	.02	.02	1.02
T X TC	1	.18	.18	9.71**
Error	44	.83	.02	-
Total	47	1.10		

**p < .01

Table 13. Test by Test Composition Analysis of Variance Summary: Vocabulary Proportion Correct

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	.00	.00	very small
Test Composition (TC)	1	.00	.00	.01
T X C	1	.00	.00	.07
Error	44	2.16	.05	-
Total	47	2.16		

Table 14. Test by Test Composition by Item Analysis of Variance Summary: Number of Fixations

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	15.67	15.67	.35
Test Composition (TC)	1	20.63	20.63	.46
Test X Test Composition	1	6.04	6.04	.14
Error (between)	44	1968.25	44.73	-
Item (I)	2	135.98	67.99	10.38***
T X I	2	135.13	67.56	10.31***
TC X I	2	34.59	17.29	2.64
T X TC X I	2	11.69	5.85	.89
Error (within)	88	576.44	6.55	-
Total	143	2904.42		

***$p < .001$

Table 15. Test by Test Composition by Item Analysis of Variance Summary: Fixation Durations

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	7367.22	7367.22	2.26
Test Composition (TC)	1	992.34	992.34	.30
T X TC	1	1308.00	1308.00	.40
Error (between)	44	143725.50	3266.49	-
Item (I)	2	5786.26	2893.13	14.69***
T X I	2	223.52	111.76	.57
TC X I	2	759.88	379.94	1.93
T X TC X I	2	677.75	338.87	1.72
Error (within)	88	17332.50	196.96	
Total	143	178172.97		

***$p < .001$

Table 16. Test by Test Composition by Correctness by Item Analysis of Variance Summary: Number of Fixations

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	217.64	217.64	2.97
Test Composition (TC)	1	17.89	17.89	.24
T X TC	1	43.36	43.36	.59
Error	32	2343.43	73.23	-
Correctness (C)	1	568.42	568.42	29.28***
T X C	1	14.26	14.26	.73
TC X C	1	4.87	4.87	.25
T X TC X C	1	37.74	37.74	1.94
Error	32	621.19	19.41	-
Item (I)	1	46.40	46.40	2.45
T X I	1	19.29	19.29	1.02
TC X I	1	15.10	15.10	.80
T X TC X I	1	5.70	5.70	.30
Error	32	605.79	18.93	-
C X I	1	3.40	3.40	.22
T X C X I	1	7.04	7.04	.46
TC X C X I	1	8.64	8.64	.56
T X TC X C X I	1	.00	.00	very small
Error	32	489.67		
Total	143	5069.85		

***p < .001

Table 17. Test by Test Composition by Correctness by Item Analysis of Variance Summary: Fixation Durations

Source	df	Sum of Squares	Mean Squares	F
Test (T)	1	5854.37	5854.37	.90
Test Composition (TC)	1	7286.62	7286.62	1.12
T X C	1	28.03	28.03	.00
Error	32	208523.25	6516.35	-
Correctness (C)	1	3404.55	3404.55	1.10
T X C	1	573.72	573.72	.19
TC X C	1	2938.61	2938.61	.95
T X TC X C	1	741.71	741.71	.24
Error	32	99070.50	3095.95	-
Item (I)	1	1624.11	1624.11	.46
T X I	1	1500.08	1500.08	.42
TC X I	1	1899.51	1899.51	.54
T X TC X I	1	707.50	707.50	.20
Error	32	113382.56	3543.21	-
C X I	1	247.71	247.71	.08
T X C X I	1	15944.63	15944.63	5.14*
TC X C X I	1	7548.16	7548.16	2.43
T X TC X C X I	1	1098.98	1098.98	.35
Error	32	99360.00	3105.00	-
Total	143	571734.06		

*$p < .05$

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